PB82-235995

Evaluation of Organic Contamination of Water by Reverse Osmosis Concentration System

Monsanto Research Corp.
Dayton, OH

Prepared for

Industrial Environmental Research Lab.
Cincinnati, OH

Mar 82

U.S. Department of Commerce
National Technical Information Service
NTIS

EPA 600/7-82-007
March 1982

PB82-235995

EVALUATION OF ORGANIC CONTAMINATION OF WATER BY REVERSE OSMOSIS CONCENTRATION SYSTEM

B. Mason Hughes
William H. Hedley

Monsanto Research Corporation
1515 Nicholas Road
Dayton, Ohio 45407

Stephen C. Lynch

Gulf South Research Institute
P.O. Box 26518
New Orleans, LA 70186

Contract 68-03-2550
Work Directive No. 14

Project Officer

Mr. Thomas Baugh

Industrial Environmental Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

May 1981

INDUSTRIAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

JR7/G

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-600/7-82-007	ORD Report	PB82 235995

4. TITLE AND SUBTITLE
Evaluation of Organic Contamination of Water by Reverse Osmosis Concentration System

5. REPORT DATE
March 1982 (paration)

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
William H. Hedley
B. Mason Hughes
Monsanto Research Corp.
Stephen C. Lynch
Gulf South Research Institute

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Monsanto Research Corporation
1515 Nicholas Road
Dayton, OH 45407
Gulf South Research Institute
P.O. Box 26518
New Orlean, LA 70186

10. PROGRAM ELEMENT NO.
1NE832

11. CONTRACT/GRANT NO.
68-03-2550; T1014

12. SPONSORING AGENCY NAME AND ADDRESS
Energy Pollution Control Division
Industrial Environmental Research Laboratory
Office of Research and Development
US EPA, Cincinnati, OH 45268

13. TYPE OF REPORT AND PERIOD COVERED
Final

14. SPONSORING AGENCY CODE
EPA 600/12

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The objective of this program was to determine whether the membrane or other components of the reverse osmosis system used to concentrate water samples for health effects testing was itself adding significant quantities of organic impurities to them. Two batches of very pure, low organic-content water from Well 4, Villa West, in Hammond, Louisiana, were concentrated using this system and both the raw water and the concentrates were analyzed by glass capillary gas chromatography/mass spectrometry. The analyses showed that chromatographable, organic contaminants in the 1-10 ppb range, (consisting mainly of silicones and phthalates) were present in sample concentrates and blanks. It is concluded that the reverse osmosis systems used do not contribute chromatographable organic pollutants in the processed waters at concentrations exceeding 10 ppb.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release Unlimited	Unclassified	28
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

EPA Form 2220-1 (9-73)

DISCLAIMER

This report has been reviewed by the Industrial Environmental Research Laboratory-Cincinnati, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names of commercial products constitute endorsement of recommendation for use.

FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory - Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This study used two samples of very pure, low organic-content groundwater that was concentrated using the reverse osmosis system. The study determined whether the membrane or other components of the reverse osmosis system used to concentrate water samples for health effects testing was itself adding significant quantities of organic impurities.

David G. Stephan
Director
Industrial Environmental Research Laboratory
Cincinnati

ABSTRACT

The objective of this program was to determine whether the membrane or other components of the reverse osmosis system used to concentrate water samples for health effects testing was itself adding significant quantities of organic impurities to them. Two batches of very pure, low organic-content water from Well 4, Villa West, in Hammond, Louisiana, were concentrated using this system and both the raw water and the concentrates were analyzed by glass capillary gas chromatography/mass spectrometry. The analyses showed that chromatographable, organic contaminants in the 1-10 ppb range, (consisting mainly of silicones and phthalates) were present in sample concentrates and blanks. It is concluded that the reverse osmosis systems used, do not contribute chromatographable organic pollutants in the processed waters at concentrations exceeding 10 ppb.

CONTENTS

	Page
Abstract	iii
1. Introduction	1
2. Summary	3
3. Collection and Concentration of Water Samples	4
Characterization of Well Water	4
Concentration of Well Water	4
4. Analyses of Water Samples	9
Procedure	9
Results	13
5. Discussion of Results	19

FIGURES

Number		Page
1	Total ion chromatogram obtained from the $(GC)^2/MS$ analysis of a performance standard. (See Table 7 for the identifications of the numbered peaks)	11
2	Total ion chromatogram obtained from the $(GC)^2/MS$ analysis of a polynuclear aromatic hydrocarbon standard. (See Table 8 for the identification of the numbered peaks)	12
3	Comparison of total ion chromatograms obtained from the $(GC)^2/MS$ analyses of base/neutral fraction of Hammond I and Hammond II water sample extracts and the analysis of the method blank, reagent blank, and instrument blank	14
4	Comparison of total ion chromatograms obtained from the $(GC)^2/MS$ analysis of acid fraction of Hammond I and Hammond II water sample extracts and the analyses of the method blank, reagent blank, and instrument blank	15
5	Comparison of mass 73 ion chromatogram with total ion chromatogram obtained from the $(GC)^2$ analysis of the acid fraction of the acid fraction of the Hammond I water extract. . .	16
6	Comparison of mass 73 ion chromatogram with total ion chromatogram obtained from the $(GC)^2/MS$ analysis of the acid fraction of the Hammond II water extract.	17
7	Mass spectra of compound eluting at 18.2 minutes for the Hammond I acid fraction	18
8	Mass spectra of compound eluting at 29.8 minutes for the Hammond I acid fraction	18

TABLES

Number		Page
1	Analytical Results from Selected Chemical Analysis of Water from Well 4, Villa West, Hammond, Louisiana.	5
2	Sampling Data, Hammond I.	5
3	Sampling Data, Hammond II	6
4	Summary Process Log, Hammond I.	6
5	Summary Process Log, Hammond II	7
6	Total Organic Carbon (TOC) Analytical Data for the Samples Collected	7
7	Components of the Performance Standard used to Evaluate the Capillary Chromatographic Analysis System.	10
8	Components of a Polynuclear Aromatic Standard Used to Evaluate Capillary Chromatographic Analysis System	13

SECTION 1

INTRODUCTION

Reverse osmosis systems have been used for field concentrations of water samples for health effects testing. By passing impure water samples into reverse osmosis systems, pure water can be removed through the membranes leaving the impurities concentrated in the remaining water. Passage of the impure water through the reverse osmosis system again raises the concentration of impurities in the remaining water manyfold; this is of real advantage for health effects testing.

In late September 1979, two samples of groundwater near a planned in situ oil shale retorting project were collected by Gulf South Research Institute (GSRI) and concentrated for subsequent use in health effects testing by the Environmental Protection Agency (EPA). The initial project plans at that time were to sample groundwater sources in the immediate vicinity of the retort both before and after the initial burn to use these test data to determine potential effects of the in situ burning process. The in situ burn has been postponed indefinitely, and an effort is being made to use an organically clean drinking water source to establish a base with which to compare the preburn retort zone water samples.

A question arose, however, as to whether or not the reverse osmosis field concentrator system used by GSRI added any impurities of its own to the concentrate. Since the water is in contact with the reverse osmosis membranes as well as other parts of the system, it is possible that they could add contaminants to the water which were not originally present.

This work was done in order to determine the identity and concentrations of any impurities added by the field concentrator. A source of very pure water with very little organic contamination was located at Well 4, Villa West, Hammond, Louisiana. Two batches of water from this well were concentrated in the field concentrator, and the water before and after concentration was analyzed for organics.

SECTION 2

SUMMARY

Two groundwater samples were collected and concentrated during the fall of 1980 at Well 4, Villa West, Hammond, Louisiana, by GSRI personnel. The samples were shipped to the Environmental Protection Agency (EPA) laboratory in Cincinnati, Ohio, for health effects testing.

Membrane rejection of organics were monitored by determining the total organic carbon levels of the source waters, concentrates, and permeates during the concentration. The average overall organic rejections for the systems were 85 and 79 percent for the Hammond I and Hammond II concentrations, respectively. TOC contents of the concentrates were 9.4 ppm for the Hammond I and 7.4 ppm for the Hammond II samples.

Samples of the feed water and each of the final concentrates were analyzed by Monsanto Research Corporation personnel using a glass capillary gas chromatograph mass spectrometer system. These samples showed that the chromatographable organic impurities found in the concentrates were in the 1-10 ppb range (assuming a sensitivity equal to anthracene-d_{10}). The impurities consist mainly of silicones and phthalates and were present not only in the Hammond I and Hammond II concentrates, but also in laboratory method blanks. Hence, the contribution of chromatographable organic compounds to waters concentrated by the GRSI reverse osmosis system are at or below these very low levels.

SECTION 3

COLLECTION AND CONCENTRATION OF WATER SAMPLES

CHARACTERIZATION OF WELL WATER

The process data included in this report was obtained during the field concentratations at Hammond, Louisiana. The water was collected at well number 4, Villa West. Selected chemical analysis of the water prior to its concentration was performed and the results are summarized in Table 1. This water represents an excellent quality groundwater. Two samples were collected and concentrated from this water source (Hammond I and Hammond II). They were collected back to back, and the only difference between them is that the membrane systems were changed between samples.

CONCENTRATION OF WELL WATER

The waters sampled for health effects studies were collected and concentrated in the field using a concentrator based on reverse-osmosis technology. This sampling equipment had also been used on several previous EPA programs (contracts 68-03-2194, 68-03-2367, and 68-03-2713) to concentrate municipal drinking waters for health effects studies. The water to be sampled is fed to a cellulose acetate reverse-osmosis system. The permeate from the module is discarded, and the concentrate is recycled and used again as feed. The water is processed batchwise until the original volume of water has been reduced to a volume suitable for shipment and until a concentration level of organics has been achieved that is adequate for health effects studies. The final concentrate from each water source is sterile-filtered to prevent biological activity and resulting organic chemical changes in the samples during shipment and storage.

Sampling data for Hammond I and II are listed in Tables 2 and 3, respectively. Summary process logs are presented in Tables 4 and 5. TOC sample logs are presented in Tables 6 and 7.

TABLE 1. ANALYTICAL RESULTS FROM SELECTED CHEMICAL ANALYSIS OF WATER FROM WELL 4, VILLA WEST, HAMMOND, LOUISIANA

INORGANIC:		
pH		8.6
Conductivity		230 µmho/cm
Total hardness		2 mg/L (as $CaCO_3$)
Silica		60 mg/L (SiO_2)
Sulfide		<0.1 mg/L (as H_2S)
ORGANIC:		
Chloroform	($CHCl_3$)	ND†
Dichlorobromomethane	($CHCl_2Br$)	ND
Chlorodibromomethane	($CHBr_2Cl$)	ND
Bromoform	($CHBr_3$)	ND
Carbon tetrachloride	(CCl_4)	ND
1,1,1-Trichloroethane	(CH_3CCl_3)	ND
Trichloroethylene	($CHCl=CCl_2$)	ND
Tetrachloroethylene	($CCl_2=CCl_2$)	ND
Total organic carbon	(TOC)	0.45 mg/L

Sampled 3/4/80 from Well 4, Villa West.

†Not detected. Detection limit of the analytical method for the chlorinated hydrocarbons is 0.5 ppb.

TABLE 2. SAMPLING DATA, HAMMOND I

Source	Well 4, Villa West, Hammond, LA
Sampling dates	September 20 - September 24, 1980 (flush September 18-19, 1980)
Volume of water processed	1050 gallons (3.97 m^3)
Final concentrate volume and concentration factor	15 gallons of 70X (0.0568 m^3)
Final concentrate TOC	9.40 ppm

TABLE 3. SAMPLING DATA, HAMMOND II

Source	Well 4, Villa West, Hammond, LA
Sampling dates	September 26-28, 1980 (flush September 24-25, 1980)
Volume of water processed	1050 gallons (3.97 m^3)
Final concentrate volume and	15 gallons of 70X (0.0568 m^3)
Final concentrate TOC	7.35 mg/L

TABLE 4. SUMMARY PROCESS LOG, HAMMOND I

Date	Time	Salt rejection, percent	Operating pressure, psig	pH
9/20/80	11:00	91	415	5.9
9/20/80	16:45	90	--	6.7
9/20/80	19:15	90	400	6.6
9/21/80	07:30	90	410	6.8
9/21/80	18:30	90	415	6.2
9/21/80	22:30	91	415	6.2
9/22/80	07:00	90	425	4.7
9/22/80	15:30	89	415	7.3
9/22/80	20:00	91	430	6.6
9/23/80	07:15	90	430	6.4
9/23/80	10:30	91	410	5.1
9/23/80	18:45	88	400	3.1
9/24/80	07:15	90	400	5.6
9/24/80	10:20	90	340	6.4
9/24/80	11:45	92	340	5.9
9/24/80	15:45	92	360	6.2
Average for concentration run		90	400	6.0

TABLE 5. SUMMARY PROCESS LOG, HAMMOND II

Date	Time	Salt rejection, percent	Operating pressure, psig	pH
9/26/80	07:45	93	315	5.3
9/26/80	10:45	94	315	5.7
9/26/80	22:30	94	315	6.3
9/27/80	07:45	93	320	6.6
9/27/80	10:30	94	320	6.6
9/27/80	22:00	92	315	6.9
9/28/80	09:30	94	310	6.4
9/28/80	16:00	94	300	5.6
Average for concentration run		94	314	6.2

TABLE 6. TOTAL ORGANIC CARBON (TOC) ANALYTICAL DATA FOR THE SAMPLES COLLECTED

Sample description	Estimated concentration level	TOC, ppm
I. Hammond I Samples		
Feed water	1X	0.28
Concentrated feed - pair one - batch 1	1.3X	1.11
Permeate of concentrated feed - pair one - batch 1	--	0.56
Concentrated feed - pair two - batch 2	2.5X	1.11
Permeate of concentrated feed	--	0.34
Pair two - batch 2 - final concentrate	70X	9.40
II. Hammond II Samples		
Feed water	1X	0.23
Concentrated feed - pair one - batch 1	3.1X	1.17
Permeate of concentrated feed - pair one - batch 1	--	0.25
Concentrated feed - pair two - batch 2	1.1X	0.53
Permeate of concentrated feed - pair two - batch 2	--	0.19
Final concentrate	70X	7.35

Several effects were observed during the reverse-osmosis concentration of both the Hammond samples. The water temperature is significantly higher than that of waters previously encountered, especially from a groundwater source. The refrigeration system for the concentrator is designed to operate on water nearer to room temperature (~25°C) and because of this heavy heat load, operation temperatures were somewhat higher than target values of 15°C. Operational temperatures averaged approximately 8°C above target values.

Color was evident in the concentrated water. A slight brownish color was evident at 10X concentration levels, and at 70X the color was similar to that of iced tea. The cause of the color was not determined.

A hydrated gel-type precipitate fell out of solution after the concentrate was removed from the concentrator. This precipitate was probably a silicate compound similar to materials encountered in other water concentrates (e.g., Poplarville, Mississippi). Operationally, the precipitate did not interfere with the reverse-osmosis concentration but did necessitate prefiltration prior to sterile filtration to prevent plugging of the bacterial filter. This was accomplished by Buchner funnel filtration with prewashed, baked, glass fiber filter disks as the filter media.

SECTION 4

ANALYSES OF WATER SAMPLES

The raw water from Well 4 and two water concentrates were analyzed for organic contaminants. These samples were extracted to produce base/neutral and acid-extractable fractions, which were then analyzed using a capillary column gas chromatography/mass spectrometer [$(GC)^2$/MS] system.

PROCEDURE

Sample Extraction

One-liter water samples, obtained from GSRI, were extracted for base/neutral and acid-extractable compounds using the protocol published by the Environmental Protection Agency in the December 3, 1979 Federal Register. Samples were extracted with 210 mL methylene chloride (90/60/60) after adjusting the pH to 11. This base/neutral extract was dried, using an anhydrous sodium sulfate column, and concentrated to 1 mL. The acid extract was obtained by extracting the remaining water sample with 180 mL methylene chloride (60/60/60) after adjusting the pH to 2. This extract was also dried, using an anhydrous sodium sulfate column, and concentrated to 1 mL. The 1-mL base/neutral and acid concentrates were transferred to a sample vial and sealed.

$(GC)^2$/MS Analysis of Extracts

Before analyzing for base/neutral or acid compounds, the two 1-mL sample extracts from each sampler were spiked with 20 µg anthracene-d_{10}, which was used as an instrumental internal standard. Since the 1-mL extract represents the total extractables from 1 liter of water (assuming 100 percent extraction efficiency), this level of anthracene-d_{10} corresponds to 20 parts per billion (ppb) in the starting water sample.

Analyses were performed using a 30 m x 0.3 mm fused silica capillary column coated with SE-54, supplied by J & W Scientific Inc. This column was installed in a Hewlett-Packard model 5985 GC/MS system, equipped with a 5840 gas chromatograph with splitless capillary injector. The capillary column was interfaced directly to within 1 cm of the ion source. The mass spectrometer multiplier volatage was 2500 volts and the threshold for data acquisition was 50 counts. The column oven temperature was held at 50°C

for four minutes and then programmed to 280°C at a rate of 8°C/min.

Figures 1 and 2 show the total ion chromatograms obtained from the analysis of a performance standard and a mixture of polynuclear aromatic hydrocarbons, using the above system. Tables 7 and 8 give the identifications of the numbered peaks given in these figures. The total amount of each component injected into the $(GC)^2/MS$ system ranged from 30 to 80 nanograms. The fact that highly basic and acidic compounds such as dimethylaniline, dimethylphenol, and pentachlorophenol produce chromatographic peaks with widths very nearly the same as measured for the nonpolar alkanes and alkene in the performance standard, indicates that the total analysis system is highly inert and apolar. The good chromatographic resolution of the benzo(a)anthracene from chrysene and benzo(a)pyrene from benzo(e)pyrene in the polynuclear hydrocarbon standard indicates that the analytical system can yield isomeric information for a wide range of compounds in the event extractable compounds are identified in the water extracts.

TABLE 7. COMPONENTS OF THE PERFORMANCE STANDARD USED TO EVALUATE THE CAPILLARY CHROMATOGRAPHIC ANALYSIS SYSTEM

Peak number	Compound
1	2,6-Dimethyl phenol
2	2,6-Dimethyl aniline
3	Decanol
4	Pentachlorophenol
5	Anthracene-d_{10}
6	C_{18}-alkene
7	C_{18}-alkane
8	Decafluorotriphenylphosphine (DFTPP)
9	C_{20}-alkane
10	C_{21}-alkane
11	Pyrene
12	Methyl sterate
13	Chrysene

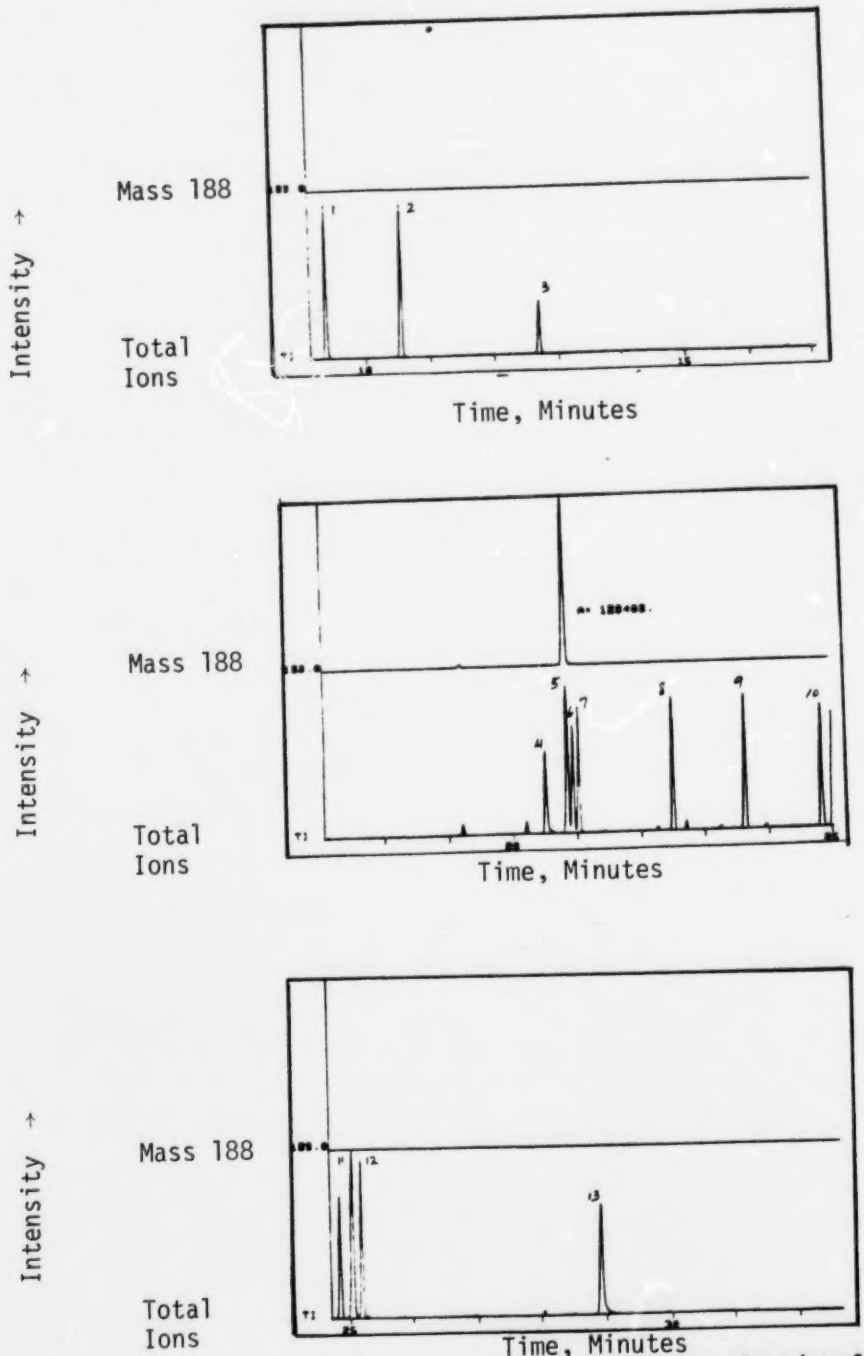

Figure 1. **Total ion chromatogram obtained from the $(GC)^2/MS$ analysis of a performance standard. (See Table 7 for the identifications of the numbered peaks).**

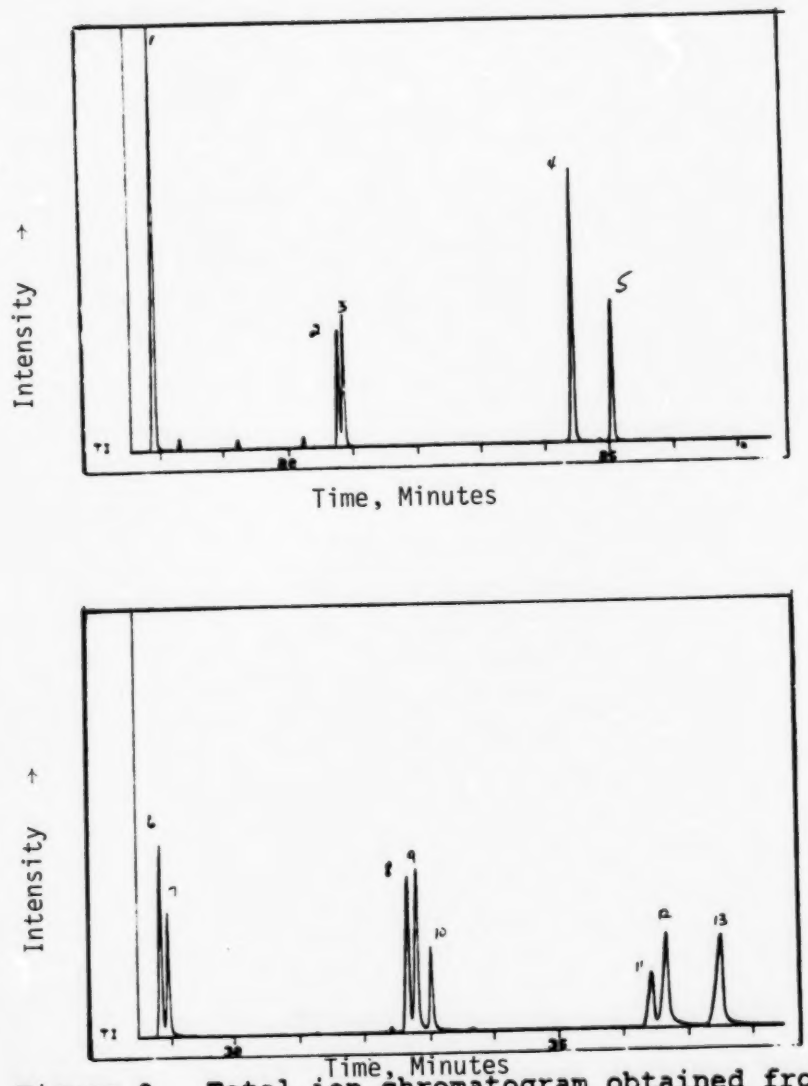

Figure 2. Total ion chromatogram obtained from the $(GC)^2/MS$ analysis of a polynuclear aromatic hydrocarbon standard. (See Table 8 for the identification of the numbered peaks).

TABLE 8. COMPONENTS OF A POLYNUCLEAR AROMATIC STANDARD USED TO EVALUATE CAPILLARY CHROMATOGRAPHIC ANALYSIS SYSTEM

Peak number	Compound
1	Fluorene
2	Phenanthrene
3	Anthracene
4	Fluoranthene
5	Pyrene
6	Benzo(a)anthracene
7	Chrysene
8	Benzo(a)pyrene
9	Benzo(e)pyrene
10	Perylene
11	Indeno(1,2,3-cd)pyrene
12	Dibenzo(a,h)anthracene
13	Benzo(g,h,i)perylene

RESULTS

Figures 3 and 4 compare the $(GC)^2/MS$ chromatograms obtained from the analysis of the base/neutral and acid fractions of the Hammond I and Hammond II water extracts with method blank, reagent blank, and instrument blank. These three types of blank analyses were conducted in order to define the possible sources of low level contaminants which may not originate from the water samples of interest. The method blank will include any background levels of contaminants associated with the overall extraction of a water sample, including glassware, solvents and the analytical system used. The reagent blank will include contaminants only from the methylene chloride extraction reagent used, and the instrument blank will only include contaminants from the $(GC)^2/MS$ analysis system.

The method blank was generated by extracing 1-liter of organic-free water, using the extraction protocol and representative glassware and solvents which were used in the extraction of the water samples under study. The reagent blank was generated by taking the total volume of methylene chloride which was typically used in the base/neutral or acid extraction and concentrating to 1 mL, using the concentration protocol and representative glassware which was used for sample concentration. The instrument blank was obtained by analyzing methylene chloride, with no concentration, using the $(GC)^2/MS$ analysis protocol used for sample analysis. Extracts of the unconcentrated feed water were

also analyzed and showed levels of impurities similar to those shown for the method blanks in Figures 3 and 4. The cleanest samples shown in Figures 3 and 4 are the instrument blank, followed by the reagent blank, which contained small amounts of components eluting in the 18 to 28 minute retention time range. The base/neutral extracts of the method blank and Hammond I and Hammond II water extracts appear to be very similar in the levels and type of compounds present. However, the analysis of the acid fraction of the water extracts shown in Figure 4 indicates that impurities are present in the Hammond I extract that elute with retention time of 18.2 minutes.

More complete displays of the total $(GC)^2/MS$ elution times are shown in Figures 5 and 6. Figure 5 shows that in addition to the component eluting at 18.2 minutes, there is also a larger component which elutes at 29.8 minutes. The Hammond II acid extract, shown in Figure 6, does not show such large amounts of these compounds, although they are present at approximately 0.1 the concentration shown in Figure 5 for the Hammond I acid extract.

Figures 5 and 6 also show the ion chromatograms of m/e 73 obtained in the analysis of the acid fraction of Hammond I and Hammond II water samples. This mass is characteristic of silicones and the simultaneous maximum in this display and in the total ion chromatogram display, shown below the m/e 73 ion chromatogram, identifies most of the low-level components as silicones.

Figures 7 and 8 show the mass spectra for the peaks eluting at 18.2 and 29.8 minutes in the Hammond I acid extract analysis shown in Figure 5. The mass spectrum for the compound eluting at 29.8 minutes agrees very closely with that of either diisooctyl phthalate, dioctyl phthalate, or bis(2-ethylhexyl)phthalate. The identity of the compound eluting at 18.2 minutes is unknown.

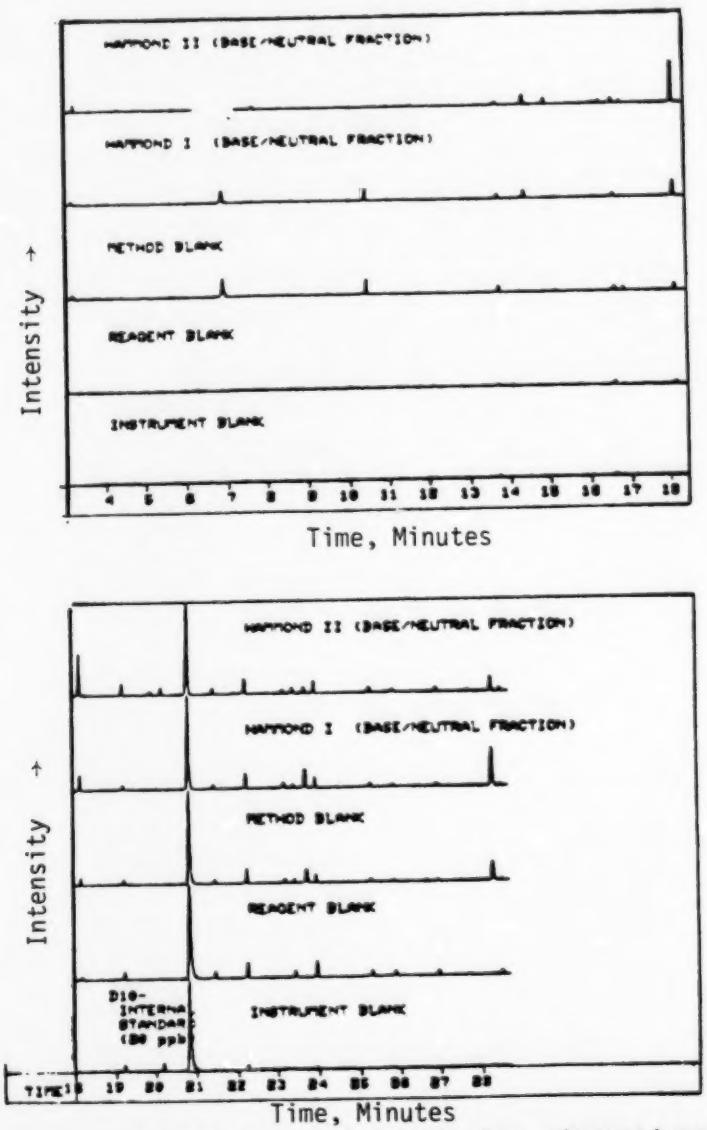

Figure 3. Comparison of total ion chromatograms obtained from the $(GC)^2/MS$ analyses of base/neutral fractions of Hammond I and Hammond II water sample extracts and the analysis of the method blank, reagent blank, and instrument blank.

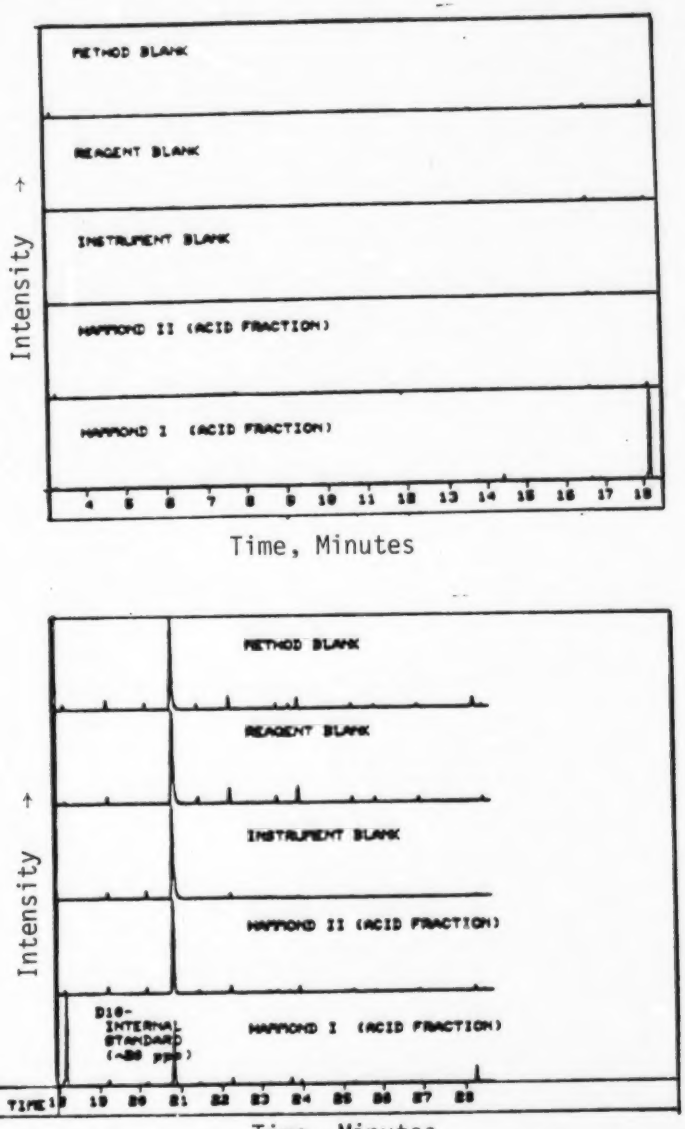

Figure 4. Comparison of total ion chromatograms obtained from the $(GC)^2/MS$ analyses of the acid fraction of Hammond I and Hammond II water saple extracts and the analyses of the method blank, reagent blank, and instrument blank.

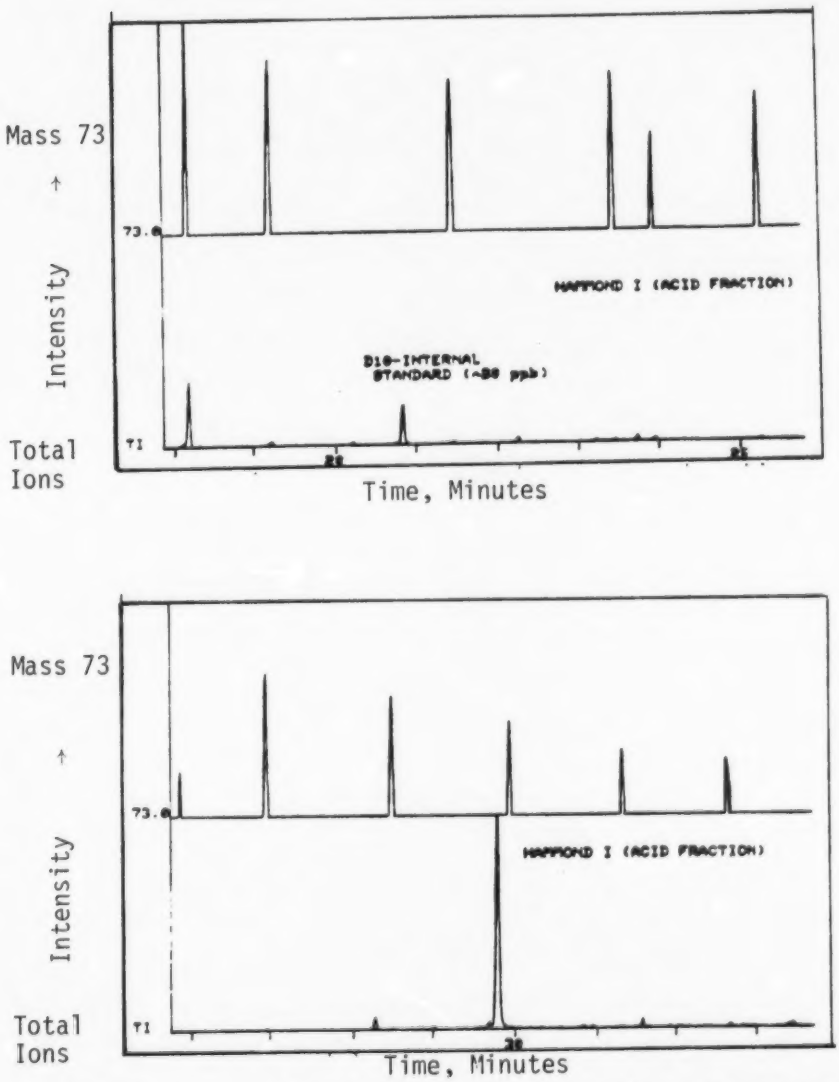

Figure 5. Comparison of mass 73 ion chromatogram with total ion chromatogram obtained from the $(GC)^2$ analysis of the acid fraction of the Hammond I water extract.

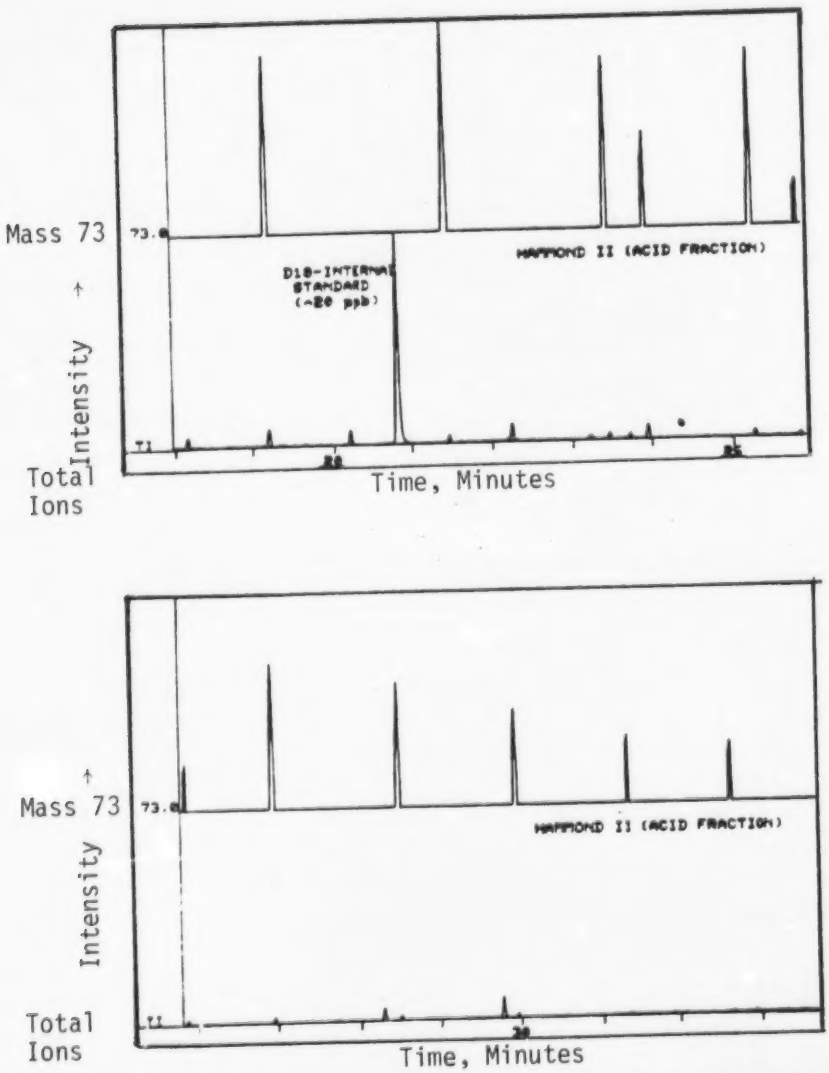

Figure 6. Comparison of mass 73 ion chromatogram with total ion chromatogram obtained from the $(GC)^2/MS$ analysis of the acid fraction of the Hammond II water extract.

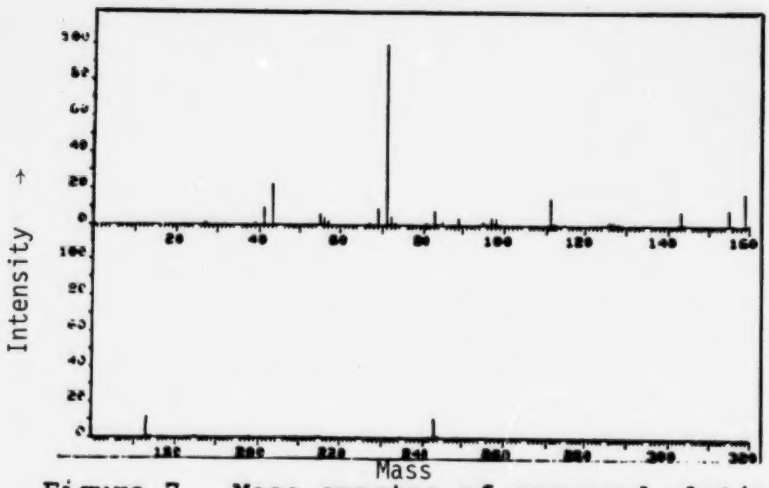

Figure 7. Mass spectra of compound eluting at 18.2 minutes for the Hammond I acid fraction.

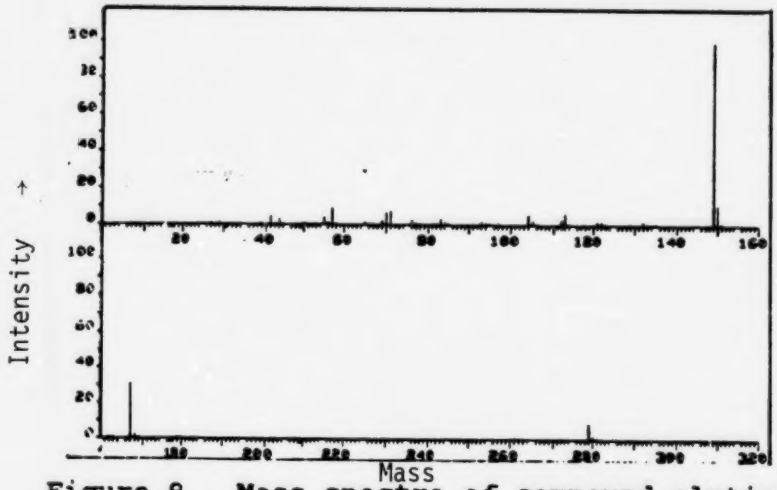

Figure 8. Mass spectra of compound eluting at 29.8 minutes for the Hammond I acid fraction.

5. DISCUSSION OF RESULTS

The Hammond I and Hammond II base/neutral extracts did not contain any chromatographable component that was not also present in the base/netural method blank extract. The components present in these samples and in the method blank are in the 1 to 10 ppb range (assuming sensitivities equal to anthracene-d_{10}) and consist mainly of silicones and phthalates. The source of these compounds is unknown, but their presence in the method blank limits our detection of these compounds in the Hammond I and II samples to approximately 10 ppb. However, the level of detection for other compounds, not present in the method blank, is probably approximately 1 ppb.

The acid fraction of the Hammond II water sample also contains components and levels of components very similar to the method blank. Therefore, the Hammond II sample has less than 10 ppb of the extractable components that are present in the method blank and less than 1 ppb for components not present in the method blank. The Hammond I acid extract showed approximately 40 ppb of an unknown compound eluting at 18.2 minutes and approximately 100 ppb for a phthalate eluting at 28.2 minutes (assuming sensitivities of these two compounds equal to that of anthracene-d_{10}). However, the fact that these two compounds are also present, albeit at much lower levels, in all our method blanks, feed water extract and reagent blank, indicates that the high levels measured for these compounds in the Hammond I extract may be a result of contamination of the glassware used to extract Hammond I.

In addition, if the phthalate eluting at 28.2 minutes was actually present in the Hammond I water sample, the majority would be extracted under the basic condition of the first base/neutral extraction and would show elevated levels in the base/neutral extract for the Hammond I water sample. No increase over the method blank was observed for the phthalate or the peak eluting at 18.2 minutes; therefore, it is assumed that the increased levels of these two compounds in the acid extract of Hammond I are due to contaminated glassware.

The TOC analyses showed that the raw water contained 0.45 ppm of total organic carbon while the two concentrates contained 9.4 and 7.4 ppm. The TOC values in the concentrates are three orders of magnitude higher than the levels of detection for chromatographable organic species possibly present. This apparent discrepancy may be due to the presence of very high molecular weight organic

compounds such as humic acids in the water. These materials, which are dissolved in low concentrations in many waters, may give it the color it exhibits, but are too large to be chromatographable by the $(GC)^2/MS$ methods used.

It is concluded that for the two samples analyzed in the present study, no chromatographable compounds in excess of 10 ppb can be associated with the reverse osmosis system. Any positive results in health effects testing of samples generated with such a system must be either due to components present in a given water source, or due to effects from non-chromatographable materials from the reverse osmosis system.